DEVELOPMENT OF NOVEL COMPOSITE HOLLOW FIBER MEMBRANES AND MODULES APPLIED IN PRESSURE RETARDED OSMOSIS: FROM LABORATORY SCALE TO PILOT SCALE

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Key Words: pressure retarded osmosis, thin film composite, hollow fiber membrane

Pressure retarded osmosis (PRO) is an osmotic-energy recovering process derived from the natural phenomenon of osmosis. It can be described as a combination of forward osmosis (FO) and reverse osmosis (RO). As for FO, PRO requires streams with two different salinities. As for RO, the applied hydraulic pressure must be lower than osmotic pressure difference for the osmotically driven flux to occur. The optimal applied pressure is considered to be half of the osmotic pressure difference. Driven by osmotic pressure difference, the water will move from the low salinity side to pressurized high salinity side. The increase in the volume of the high salinity solution can be used to turn a turbine or be fed to a pressure exchanger to harvest the osmotic energy. Therefore, PRO membranes must be as porous as possible for high water flux but sufficiently strong to withstand the applied hydraulic pressure and long term operation.

This study aims (1) to explore the laboratory-scale fabrication of composite hollow fiber membranes with enhanced mechanical strength for high power density PRO applications. Comprehensive experiments were designed to fabricate the porous substrate utilizing polyethersulfone (PES) and polyetherimide (PEI) as the fiber materials. A polyamide selective layer was developed on the inner side of the hollow fiber substrate; (2) to adapt the laboratory-scale module to the pilot scale. The membrane performance was then tested in a PRO pilot system under various conditions.

Laboratory-scale fabrication and testing was used to characterise the membrane properties. The laboratory-scale module consisted of 15 fibers in a 12 mm diameter module. It was found that the intrinsic properties of the fabricated membrane changed with increasing operating pressure but the membrane selectivity was stable/constant below a certain pressure. The thin film composite hollow fiber membrane is able to withstand long-term laboratory-scale PRO testing. It achieved a power density of 15 W/m^2 at an operating pressure of 12.5 bar using 1.0 M NaCl solution and DI water as the draw solution and feed water, respectively. A bigger module of 60 mm diameter containing 500 hollow fibers was prepared for testing in the pilot-scale system using DI water as feed and 1.0 M NaCl as draw solution. The results of this study are necessary for technical and economical evaluation of PRO systems.